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RECOVER, RECYCLE AND REUSE: AN EFFICIENT WAY TO REDUCE THE WASTE

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ABSTRACT

Waste management is the biggest problem for the present as well as the future world. We are creating a miserable future for the generation forced to live in this polluted world. The global metal waste alone is 1.3 billion tonnes and it is expected to grow to 27 billion tones by 2050. According to the latest report, India generates 1.57 lakh tonnes of solid waste per day. Out of which only 20% of waste is taken to the recycling path and the remaining 80% is landfills through the improper way. This 80% of waste creates a massive impact and spoils our environment. The objective of the paper is to study the extent of waste created by the world and the Indian. Further, this paper highlights the environmental impacts on human health. Finally, it gives suggestions to dispose the waste product properly without harming the environment with the help of recycling concept.

KEYWORDS: Environment, Waste, Recycle, Reduce, Recover, Reuse & Dispose

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Original Article

1. INTRODUCTION

1.1. Global Scenario

The world is moving towards urbanization and industrialization. This growth and development have created a major impact on the environment by causing land, water, air, and noise pollution through heaps of waste reduced air quality, polluted water, global warming, greenhouse gas, acid rain, etc. Dumping of huge plastic waste causes drought, as it reduces the chance of rainfall. (Liu, et. al., 2018; Ramachandra et. al., 2018).

This improper disposal of waste causes infectious and chronic diseases to humans and animals (Banerjee, et. al., 2019).

Every year we are generating a huge waste of 1.3 billion tonnes that can cover the entire world. With the current rapid urbanization and population growth, it is further expected to increase up to 2.2 billion by 2025. The world waste production is expected to grow to 27 billion tonnes per year by 2050, one-third of which will come from Asia, majorly contributed by China and India. The per capita of waste generation rate in the world is going to increase from 1.2 to 1.42 kg for the next decade. Asian countries contribute up to 1 million tonnes of waste per day. Already, the dumping yards of most of the countries like US, Japan, UK, Netherlands, etc. are full (Nitin Joshi

& D. P. Mishra, 2011). Waste is the biggest problem for the present and a challenge for future generation doomed to live in this dumping yard (earth) because of unsystematic waste management practices (Kale et. al., 2018).

According to the World-Bank report, the Asian continent spends 25 million US $ per year for cleaning-up solid waste and this is expected to increase up to 47 million US $in the near future (Coban, et. al., 2018). Despite these expenditures huge, urban areas in the Asia Pacific are still grappling with the challenge to prevent environmental degradation. According to the Central Pollution Control Board (CPCB), the global scrap metal market has been growing and is expected to reach by $ 406.2 billion by 2020. Another great problem is our polluting the marine life by throwing plastic and garbage into the ocean which has a devastating effect on the sea animals causing them to die (Ciambrone, 2018). According to the United Nations Environment Programme (UNEP), every year people around the world produce 300 million tonnes of plastic. Out of that, more than 13 million tones are found in the oceans, wreaking havoc on the marine ecosystem and the fishing industry.

1.2. Overview of India Scenario

India is located in the south of the Asian continent and is accounted as the 7th largest country in the world with an area of 3,287,263 square kilometers and the 2nd most populated country behind China. Now, at the close of 2018, the population has already touched1.36 billion and it is forecast that it will reach 1.73 billion by 2050. According to the latest newspaper reports, India generates 1.57 lakh tonnes of solid waste per day. In India, approximately 62 million tonnes of waste is produced annually (Coban, et. al., 2018). The per capita of waste generated in major Indian cities ranges from 0.2 Kg to 0.6 Kg. It is estimated to increase, especially in urban areas, to 0.7 kg per person per day by 2025. It is four to six times higher than it was in 1999.

This causes several environmental problems associated with waste. We are using improper methods of gathering waste, transportation, treatment, and even disposal. The local bodies spend around ₹500 to ₹1500 per tonne on solid waste for collection, 20 to 30% on transportation, treatment, and disposal[1]. About 60 to 70% of the above amount is spent on collection, for transportation and less than 5% on for final disposal. Further, it is estimated that during the period of 2015-2025 the waste composition of Indian garbage will undergo the following changes: *Organic waste* will growupfrom40-60%, *Paper waste* will increase from 5-15%, *Plastic waste* will rise from 4-6%, *Metal* waste will escalate from 1-4%, and *Glass* waste will limb from 2-3% (Han, et. al., 2018). At present, it is not possible to track down the environmental pedigree of parts and materials, which can vary, based on nature (Arokiaraj 2015, John M. De Cicco & Martin Thomas, 1999). This huge volume of waste is generated mainly due to population growth, and impacts the environment and affects public health (Sunil Kumar& Stephen R. Smith, 2017). The current strategic methods followed by Indians would not clear up the entire waste (Banerjee, et. al., 2019).

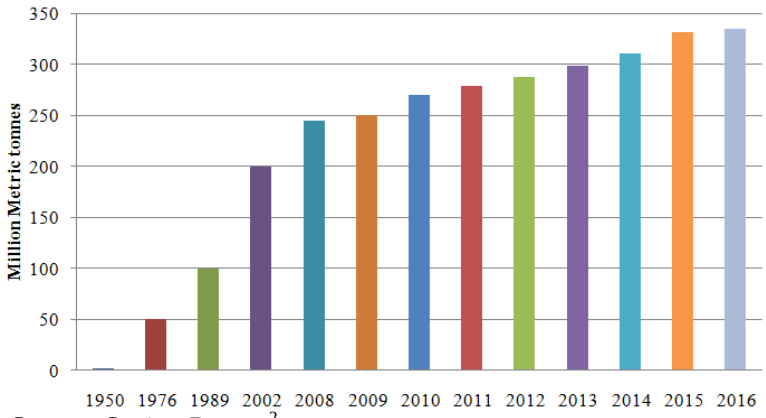
2. TYPE OF WASTE GENERATION

2.1. Plastic Waste

The production of world plastic was1.5 million metric tonnes during the 1950s. It went up to 336 million metric tonnes in 2016. Out of which, only 9% are recycled, 12% incinerated and 79% accumulated for landfills. The plastic use in Western countries has increased by roughly 4%. According to Statist a Report, the global production of plastic is continuously increasing and is expected more so in the future. Chart 1 given below, global plastic production is displayed

[1] https://www.thehindubusinessline.com/opinion/columns/theres-much-to-gain-from-recycling-of-waste/article24802735.ece

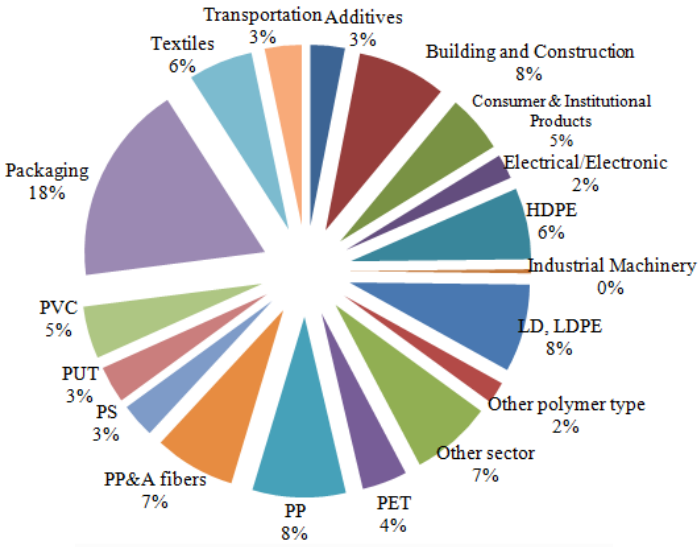
in million metric tonnes.



Source: Statista Report.[2]

Chart 1: Global Plastic Production

The below chart 2 shown that the percentage of plastic utilized by different sectors. Among that 18% of plastic is used in packaging, followed by 8% in building and construction, 7% in PPA fibers, and the remaining in others.



Source: Statista.com (The Statistics Portal, 2019).

Chart 2: Primary Plastic Production (Million Tonnes)

The per capita consumption of plastic by the top five countries are USA (109 kgs), Europe (65 kgs), China (38 kgs), Brazil (32 kgs) and India (11 kgs). India is placed in 5th position in terms of plastic consumption. The consumption of plastic in India will double by the end of 2025. The Ministry of Petroleum and Natural Gas (MOP & NG) has suggested that the per capita consumption would be doubled by 20 kilograms in 2022. This massive production and consumption of plastic make our earth indigestible. About 75% of plastic waste in the United States ends up in landfills and only 9% of plastics are recycled. The Europeans produced around 60 million tonnes of plastic in 2016, out of which only 8.4 million tonnes of plastic are recycled. Whereas, the Indians have produced more than 150 lakh tonnes of plastic in 2018, out of which around 50-60% of plastics are recycled (Arokiaraj & Banumathi, 2014a). This plastic has already created a lot of ecological imbalance and disasters all over the world. In India, it is estimated that around 0.6 million tonnes

[2]https://www.statista.com/statistics/282732/global-production-of-plastics-since-1950/.

of plastic waste are dumped into the Indian Ocean, the Bay of Bengal and the Arabian Sea via Kerala, Tamil Nadu, the Andaman and Nicobar Islands and the Mumbai regions (Bushan. D, et. al., 2017). This plastic pollution makes India one of the top 20 countries that dump maximum plastic waste into the oceans. It has directly affected the coastal ecosystem by reflecting its effects on 267 species, including 86% of sea turtle species, 43% of marine mammal species and 44% of seabird species. It has also indirectly affected the human's health through the consumption of marine foods.

It is reported that already around 5 trillion pieces of plastic have been dumped into the ocean. The decomposition period of one plastic bag will take up to 200-1000 years, one plastic bottle takes up to 500 years, one plastic cup takes up to 50-100 years, and one plastic container takes up to 50-80 years. Sadly, only 9% of plastic was recycled, 12% was incinerated, and 79% was discarded in landfills that emit several gases like carbon dioxide and methane which constitute up to 90%-98%. There are lots of benefits for recovering, reducing, recycling, reusing the plastic. First of all, using this concept will reduce the raw material utilization to a new product. Second, it can use the product again and again without dumping it into the land(Kale, et. al., 2018). Thirdly, it can avoid air, land, water, and noise pollution and finally, it can protect and preserve the natural environment(Arokiaraj. D & Banumathi. M, 2014b). Apart from that one tonne of recycled plastic can save up to 3114 liters of oil, 20,786 megajoules of electricity, 3000 liters of water, 1000-2000 gallons of gasoline and also 25m^3 of landfill space.

2.2. Paper Waste

The paper industry is classified into four segments as newsprints; specialty papers and others; packaging paper & board; and Printing &Writing (P&W). During the paper production process, the required raw materials are wood, sugarcane, chemicals-water, water, Alum & Rosin-water additives for a finished paper (David, A., & Banumathi, M., 2017). Each and every production process releases a bulk amount of wastewater. Every year, around 400 million tonne papers are produced globally. The world's three top paper-producing countries are China, the United States, and Japan. India produces 18.5 million tonnes of paper which contributes to 4% of the global production in 2018. The Indian Paper Mills Association (IPMA) estimated that the Indian paper industry turnover is more than ₹50,000 crore and provides employment opportunity to over 5 lakh people across 750 paper mills. The per capita consumption of the average Indian is 13kg of paper which is very lower compared to other countries like the United States (229kg), North America (200 kg), China (74kg), Malaysia (25kg), Indonesia (22kg), and globally (58kg). But, according to the report of India mirror, the demand for paper will raise up to 53% (20 million tonnes) by2020.

Paper pollution is another form of a problem to the natural environment. The paper industry is considered the 3rd largest polluter of air, water, noise, and soil. It is estimated that five hundred million tonnes of paper and cardboard will be produced in 2020. Nearly 80% of all grocers and retailers are using cardboard. Chlorine-based bleaches are used during the production, which results in heavy toxic materials being released into our water, air, and soil. When paper rots, it emits methane gas, which is 25 times more toxic than CO_2. Air contaminated in the paper mills is composed of chemical particulates, particulate emission, and other gases. Gases emitted are a variable mixture of hydrogen sulphide, methyl mercaptants, dimethyl sulphide, and dimethyl disulphide. There are lots of benefits for the processes of recovering, reducing, recycling, and reusing the paper again. Recycling one tonne of paper and cardboard can actually save up to 46 gallons of oil and reduce upto 75% of energy consumption. By recycling and reusing papers, we can avoid 95% of air pollution. Nearly half-million trees were cut down for Sunday newspapers alone. It is calculated that 25 pounds of recycled paper can save 17 trees, 350 gallons of oil, prevent landfills and air pollution.

2.3. Glass Waste

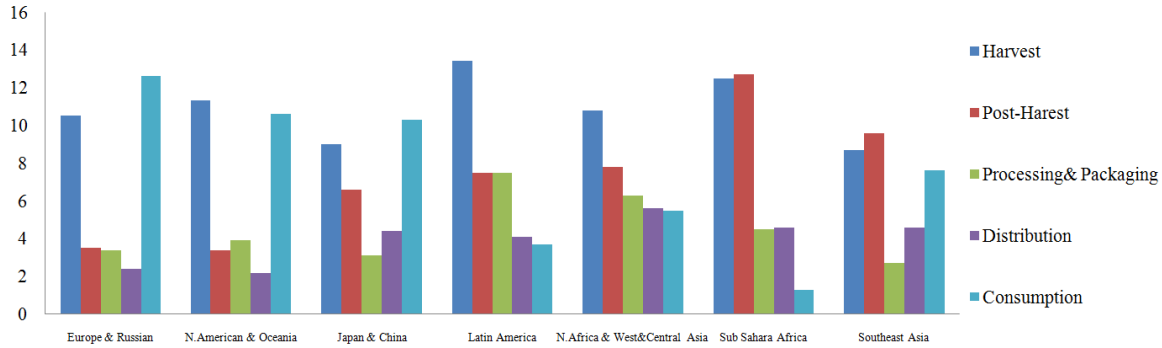
The glass is an inorganic product produced around 56.51million metric tonnes in 2018 and expected to increase to 65.43 million metric tonnes by 2022[3]. It is a melted mixture of silica sand, soda ash, limestone, with desired metallic oxides that serve as colouring agents. There are four main segments of the glass industry and these are classified into container glass (45%), flat glass (16%), fiberglass (6%) and specialty glass (33%). The world glass industry generates around $75 billion and the leading producers are the US, China, Japan, France, India, and Germany (Chaudhary & Vrat, 2018). The per capita of glass consumption in South Korea is89%, France 64%, Germany 51%, USA 28%, Turkey 6% and Brazil 5% whereas in India it is 2 kg.

The production of glass in India is estimated to rise up to 15% over the next three years. The glass consumption is also expected to increase 10-12% in construction, 20% in automotive, 15-20% in consumer goods and 15-18% in pharmaceutical sectors. Glass industry acts as a supplier of raw materials and primary sources for the other industries like architectural, automotive, value added glass, mirrors, furniture and another segment(Srivel, 2018), which has a market share of 45%, 15%, 15%, 10% & 15% respectively. According to the report of Industry Body Assocham, the Indian glass industry is worth ₹340 billion. The modern glasses will take up to 4000 years to decompose. Every year, more than 28 billion glass bottles and jars end-up in the landfills. It is calculated that, on average, a person can use 25,000 cans in their lifetime. This creates serious land and water pollution. Glass is 100% recyclable and 100% reusable. By recycling glasses, we can avoid 50% of water pollution and save 100% of the land. Further, it can also save electricity, water, land and virgin materials.

2.4. Food Waste

Food waste is one of the basic problems which mankind faces today. Today around 60% of people are hungry and among that 98% of people are living in developing and under-developed countries and they do not have sufficient nutrition(Liu, et. al., 2018). China is the world top food producer, India the second large food producer and then comes the United States. According to the Food and Agricultural Organization (FAO) roughly one-third of the food produced in the world for human consumption (1.3 billion tonnes)is wasted and among that we have cereals (30%), root crops (40-50%), fruits and vegetables (20%), oilseeds, meat, fish, dairy and others (35%)(D. Arokiaraj & R. Srivel, 2017). In fact, according to Radha Mohan Singh, the Indian Agriculture Minister, ₹58,000 – ₹96,000 crores worth of food is wasted every year in India (Banerjee, et. al., 2019). Further, the FAO stated that the per capita of food waste by the North American and the European countries is 95-115 kg, whereas Sub-Saharan Africa, South, and Eastern Asia generate6-11 kg every year. This clearly explains that the developed countries are wasting more food than the developing countries(Liu, et. al., 2018). Chart 3 given below explains the percentage of wastage generated all over the world.

[3] https://www.statista.com/statistics/700260/glass-bottles-and-containers-production-volume-worldwide/



Source: Report of Committee on World Food Security, FAO 2018.

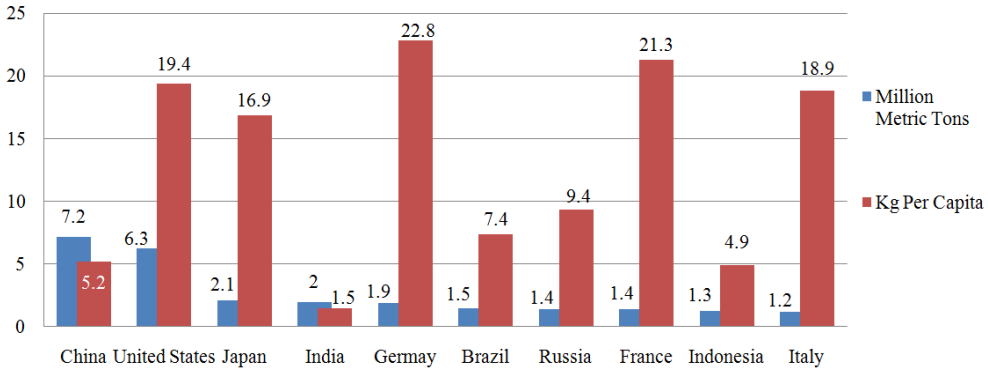
Chart 3: Percentage of World Food Wastage

A recent study of the Global Harvest Initiative (GHI) predicted that in 2050 the world population will reach 9.8 billion and 2100 (11.2 billion) and it is not possible to feed the entire population. The food scarcity problems will start from 2030 onwards. According to the Indian Minister of Food Processing, Harsimarat Kaur Badal, "My Ministry works as a catalyst. It has the potential for doing a couple of things. First of all, bring down food waste. Food is being wasted at the harvest point and also during transportation. If this food is preserved from wastage we have enough food to feed the entire hunger people, and these are also available to a common-man at a reasonable price". Another big problem is that all the social functions and social joints in India (especially in the Northern and Central parts), for instance, wedding halls, canteens, households, and hotels, spew out much food. In India, the number of hungry people has increased to 65 million and this resulted in the Global Hunger Index, 103 out of 119 (GHI[4], 2018). On the one side food is wasted and on the other side food is scarce and never reaches the needy. Further, the need for excess food will result in unnecessary utilization of natural resource - land, water, labor, capital, energy, and the waste formed leads to greenhouse gas emissions, which contribute to global warming and climate change and that could reduce ground water level.

2.5. Electronic Waste

E-waste is one of the fastest growing wastes in the world. Every year 500 million tonnes of E-waste is generated (Awasthi, & Li, 2018). According to the World Statist a Report, 20% of E-waste is recycled and the remaining 80% was undocumented, like, to-be-traded or dumped into the land. It is predicted that the amount of E-waste is going to increase 500% times in the forthcoming years, especially in Asia, with India and China considered to have the fastest growing electronic industries in the world (Chaudhary & Vrat, 2018). The per capita of E-waste generated is: China (7.2%), US (6.3%), India (2%) and others, whereas overall E-waste generated by the countries is : Germany (22.8%) followed by France (21.3%), US (19.4), Italy (18.9), and others. as shown below. Chart 4 given below explains about the per capita electronic waste generating countries.

[4] https://www.globalhungerindex.org/results/

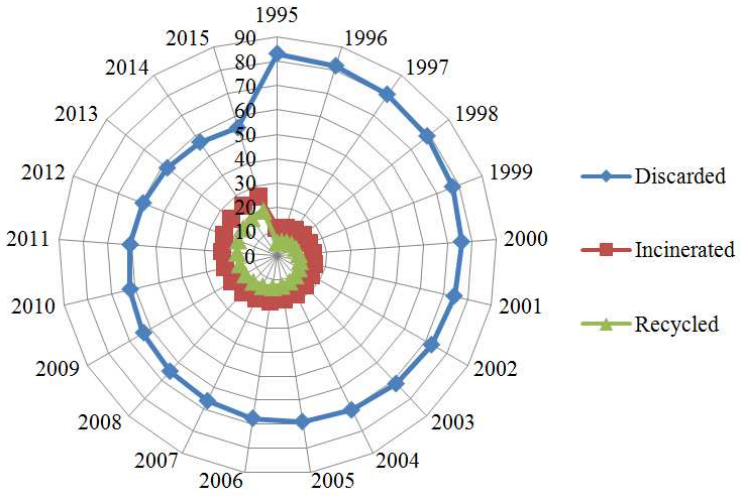


Source: The Global E-waste Monitor, 2017.

Chart 4: Electronic Waste by Top 10 Countries*

***includes discarded products with a battery or plug-includes mobile phones, laptops, televisions, refrigerators, electrical toys, and other electronic equipment's.

According to the Associated Chambers of Commerce and Industry of India (ASSOCHAM), two million tonnes of E-waste are generated per annum, among that the computer equipment (70%), telecommunication equipment (12%), electrical equipment (8%), medical equipment (7%) and other equipment (including household-crap)(4%).



Source: Down-to-earth.[5]

Chart 5: Percentage of Electronic Waste, Incinerated and Recycled

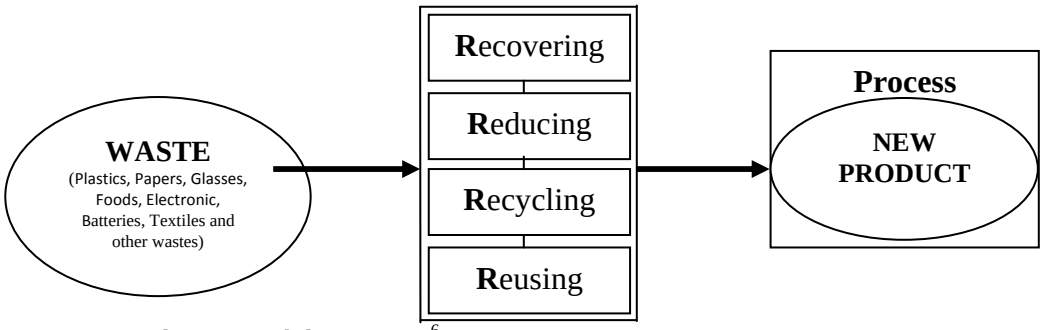
Sadly, in India, only 18% of electronic waste is recycled and the remaining82%is thrown into the garbage in landfills. This is mainly due to poor infrastructure and legislation policies. This90% of electronic waste is handled by the unorganized sector and the scrap dealers (Awasthi, & Li, 2018). The main responsibility of a dismantler is to dispose of products by breaking them into smaller parts instead of recycling them or sending them to a product company. Further, the dismantling process will affect the workers' health, as well as landfills. High and prolonged exposure to chemicals/ pollutants emitted from unsafe electronic waste will directly lead to the failure of heart, liver, respiratory disorders, skin disorders, lung cancer, bronchitis and spleen damage, blood systems, kidneys and brain, damage of nervous systems, etc. Dumping electronic waste resulted in polluting the soil, water, and air, and putting people's health in danger(Kale et. al., 2018).

[5] https://www.downtoearth.org.in/blog/waste/e-waste-disposal-what-india-can-learn-from-norway-48398

3. LITERATURE REVIEW

3.1. The Significance and Value of R's

In today's world, we are producing more "WASTE" in term of plastics, papers, glasses, foods, electronics, and others. These wastes have been discussed in the introduction section alone with their expected growth which will cause environmental damages. Each and every waste has its own value in term of economy. These wastes have already created serious effects on our natural environment and might totally collapse the entire ecosystem. These issues can be controlled and suppressed by practicing the four R's as shown in Chart 6 given below. They are Reducing, Recovering, Recycling and Reusing material/components/items/parts over and over again (Arokiaraj. D, 2011). It is not only economically lucrative but also environmentally beneficial.



Source: The Sustainability Project.[6]

Chart 6: The Process of Converting Waste into New Product

3.1.1. Recovering

Every product has its own end-stage; some parts can be recovered for the purpose of reuse. The waste materials are usually recovered at the end of the product lifecycle, and they can be used for recycling (Louppe, 2006; Miller, 2008). These recovered items can be recycled and reused in the production process. This process can ultimately avoid virgin product and avoid unnecessary expenditure on procurement. It has monetary benefits to the company by limiting virgin products. It is considered one of the best ways to avoid land filling and to reduce the environmental impact on our globe.

3.1.2. Reducing

By recovering, reusing, and recycling materials/items/components, we can actually reduce the use of natural resources like water, oil, energy, fuel, metals, gas etc. Significantly, the most effective way to reduce environmental negativity is to better design a product for the prevention of waste (Zhu et al., 2005). There are a lot of advantages in reducing the usage of new resources and reusing recovered items. First of all, it helps to avoid using virgin products and preserves natural resources. Secondly, it facilitates the usage of recovered components or parts over and over again. Thirdly, it reduces the procurement expenses by cutting down on new resources. Fourthly and the most importantly it avoids unwanted wastes, avoids land filling and also brings down the pollution level. Finally, it helps to build a sustainable future through the environment, economy, and society (Pandey, et. al., 2018).

[6] https://thesustainabilityproject.life/all-about-the-zero-waste-hierarchy/

3.1.3. Recycling

Recycling is the process of converting the old and used materials/components/items/parts for a new use, for the same purpose or for some other purpose (Banumathi&Arokiaraj,2011). In other words, recycle means, "to make products that can be reprocessed and converted into raw material to be used in another or the same product" (Prakash, 2002). The materials/components/items/parts that can be recycled are plastics, papers, glasses, electronics, batteries, textiles, and other waste. By using recycled components we can reduce virgin products. The recovered items financially save cost, as well as, environmentally avoid unwanted pollutions. A study conducted by the University of Oklahoma has found that recycled steel alone can actually reduce 97% of mining waste, save 75% of energy and also avoid 86% of air pollution and 76% of water pollution.

3.1.4. Reusing

Based on the above literature, we have discussed how environmental preservation, economy saving, and social needs can be attained by using the recover, reduce, recycle and reuse concept. Louppe (2006) and Bradley (2007) have argued that it is very important to make products through the process of recovery, recycle and reuse. Say, for example, one tonne of reused papers can save upto 4100kWh of electricity, 17 trees, 2.5 barrels of oil, and 31,780 liters of water. Likewise, one tonne of reused steel can save 287 liters of fuel oil, 1.2 tonnes of iron ore, 0.5 tonnes of limestone, 0.7 tonnes of coal, 2.3 cubic meters of landfill (Gan, et. al., 2018) and also lessen water consumption upto 40% and cut down 58% of Co_2 emission. Consequently, each and every component has its own advantages and benefits in terms of environment, economy, and society.

Table 1: Environmental Effects of Recycling

Material	Energy Saving up to	Air Pollution Reduction up to
Aluminum	95%	95%
Cardboard	24%	—
Glass	40%	20%
Newspaper	40%	73%
Plastic	70%	—
Steel	60%	—

Source: Pappu, 2007.

The above Table1 explains the percentage of saving energy and avoiding air pollution. Apart from benefitting environment, society and economy, it also creates employment opportunities in the process of converting wastage into reusable products. In the recycling segment alone, around 150,000 direct jobs and 323,000 indirect jobs will be created. In China, 1.5 million direct jobs and 10 million indirect jobs will be created. In India, around 1.75 million people are working in metal recycling segments which contribute upto 2% of Gross Domestic Product (GDP). This is also predicted to increase in 2030. Around 10.5 million people are going to work under this sector, which is expected to generate 14 lakh crores and that contributes 11% to GDP.

4. CONCLUSIONS

The study concludes that global wastage is going to rise from 1.3 billion tones in 2018 to 27 billion tones by 2050. The current regulations are not going to make zero waste. In India, we are generating massive waste every day. Already, the dumping yards were filled with these huge wastes. The government should formulate a strict regulation to make producers and users coordinate with each other in order to achieve "*zero waste, zero pollution, and zero landfills*" thereby

protect the natural environment of air, land, and water. Here, they need to implement two main things immediately, first of all, extend the producers responsibility to take back, whenever their products come to an end stage. So, it is their responsibility to take care of their products and properly dismantle them without harming the environment with zero wastage. Second, consumers or users have a responsibility to return the product to the producers and help them recycle and reuse the product and thus make monetary gain mutually. The Indian government has to create a special force to monitor the waste created by the industries as well as the consumers, state-wise, district-wise and area-wise. It also has to improve the infrastructure facilities in terms of gathering, transporting, and segregating waste. There are a lot of advantages in using the recycling concept, subject to the nature of the product. Say, for example, we can utilize food waste, paper waste, and other decomposable waste that to make natural fertilizer and enrich the soil for better cultivation.

Further, the government has to launch a strong awareness campaign to highlight the benefits of selling the scraps, from consumers-to-industries and industries-to-dismantlers and also by recognizing the potential recyclers in their area. The Government helps to identify the best recyclers, in terms of those who practice the Environmental Management System (EMS)and those who are International Standards Organization (ISO-14000)certificated dismantlers. It motivates the recyclers to adopt the international best-practices, to develop appropriate technologies, and also adopt a suitable strategy and systematic way of approaching the end-product.

5. FURTHER STUDY

Further study can develop a model and international best practices like Environmental Management System (EMS), ISO-14000 etc. to dismantle and segregate a product according to its nature. It can also extend its scope to study the complete life history of the product, starting from cradle-to-grave and make a system of cradle-to-cradle approach, through recycling. Further study can calculate the monetary benefits of selling the scrap from customers-to-industries (Users), industries-to-recyclers (Dismantlers), and recyclers-to-industries (Remanufacturers). The study can also conduct research on the health and safety of the recyclers (employees) in the scrap dumping yard and also the impact of these dumping yards on the environment.

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